PATENT COOPERATION TREATY

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34, chemin des Colombettes
1211 Geneva 20
SWITZERLAND
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AMENDMENT UNDER ARTICLE 19

Dear Madam or Sir:

Please substitute the enclosed pages 69-71, 81-82, 84-85, and 96-100 for the original pages 69-71, 81-82, 84-85, and 96-100. The enclosed pages amend the application as follows:

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(71) Applicant *(for all designated States except US)*: **ILLINOIS VALLEY HOLDING COMPANY** [US/US]; 13105 North State Route 91, Dunlap, IL 61525 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **BAILEY, John, M.** [US/US]; 13105 North State Route 91, Dunlap, IL 61525 (US). **WALDMAN, Donald, J.** [US/US]; 14409 Schlink Road, Brimfield, IL 61517 (US).

(74) Agents: **MUSGRAVE, Richard, J.** et al.; Husch & Eppenberger, LLC, 401 Main Street, Suite 1400, Peoria, IL 61602 (US).

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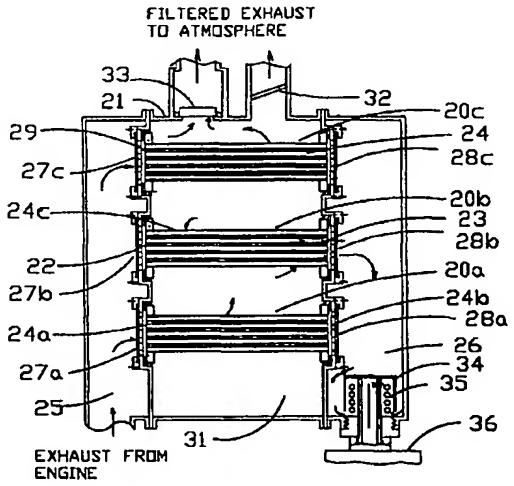
(54) Title: APPARATUS AND METHOD FOR FILTERING PARTICULATE AND REDUCING NOx EMISSIONS



(57) Abstract: An apparatus and method for filtering particulate from an internal combustion engine by use of monolithic particulate trap systems having porous walls (2c, 24c). The porous walls (2c, 24c) filter the particulate. The filtered particulate on inner surfaces of the porous walls is periodically removed or regenerated via back flow of previously filtered exhaust gas. The back flow is caused by creating a pressure difference across the porous walls. The back flow of the previously filtered exhaust gas is simultaneously or sequentially coupled with high velocity through flow of exhaust gas in the channels. In addition, the particulate trap system can be an adsorber-catalyst particulate trap system for filtering particulate and reducing NOx via an adsorber-catalyst trap systems to achieve the EPA 2007 standards.

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Replaced by Am 19 Amd't.

What is claimed is:

1. A particulate trap system for an internal combustion engine, comprising:

at least one particulate trap module positioned to accept engine exhaust gas including a plurality of passages having porous walls for receiving the exhaust gas, wherein the porous walls filter particulate from the exhaust gas; and

means for periodically reversing a portion of the filtered exhaust gas back through the porous walls in reverse flow at sufficient pressure drop and resultant flow velocity to dislodge and erode any build-up of soot and ash from the porous walls.

2. The particulate trap system according to claim 1, wherein the at least one particulate trap module is at least one monolithic cross flow trap module having a plurality of through flow passages.

3. The particulate trap system according to claim 1, wherein the at least one monolithic particulate trap module is at least one wall flow trap module.

4. The particulate trap system according to claim 2, further including:

an entrance chamber for receiving the exhaust gas from the engine and operatively connected to a first side of the at least one particulate trap module;

a separation chamber operatively attached to a second side of the at least one particulate trap module and for receiving some of the exhaust gas from the at least one particulate trap module; and

an exit chamber for receiving the filtered exhaust gas passing through the porous walls of the at least one particulate trap.

5. The particulate trap system according to claim 4, further including:

means for creating a pressure difference between the separation chamber and the exit chamber in response to a pre-established engine operating condition, wherein the pressure in the exit chamber is greater than the pressure in the separation chamber, thereby forcing the filtered exhaust gas from the exit chamber back through the porous walls to dislodge and blow out the build-up of soot and ash on inner surfaces of the porous walls.

6. The particulate trap system according to claim 5, wherein the means for creating the pressure difference between the separation chamber and the exit chamber is a pressure relief valve operatively mounted to the exit chamber for creating pressure build-up in the exit chamber, thereby forcing the filtered exhaust gas from the exit chamber back through the porous walls to dislodge and blow out the build-up of soot and ash on the inner surfaces of the porous walls.

7. The particulate trap system according to claim 5, wherein the means for creating the pressure difference between the separation chamber and the exit chamber is a venturi operatively mounted to the exit chamber and operatively connected to the separation chamber, wherein the venturi increases pressure in the exit chamber and reduces the pressure in the

separation chamber, thereby forcing the filtered exhaust gas from the exit chamber back through the porous walls to dislodge and blow out the build-up of soot and ash on the inner surfaces of the porous walls.

8. The particulate trap system according to claim 5, wherein the means for creating the pressure difference between the separation chamber and the exit chamber is a pressure relief valve operatively mounted to the exit chamber valve for creating pressure build-up in the exit chamber, and a venturi operatively mounted to the exit chamber and operatively connected to the separation chamber, wherein the venturi increases pressure in the exit chamber and reduces the pressure in the separation chamber, thereby forcing the filtered exhaust gas from the exit chamber back through the porous walls to dislodge and blow out the build-up of soot and ash on the inner surfaces of the porous walls.

9. The particulate trap system according to claim 8, wherein the at least one valve precluding exhaust gas from entering the at least one particulate trap module from the entrance chamber allows exhaust gas to enter and flow through the through flow passages to blow out the removed soot and ash and to erode any additional soot and ash.

10. The particulate trap system according to claim 9, further including:

an igniter for burning the soot; and

a chamber for storing the ash.

11. The particulate trap system according to claim 5, further including:

the filtered exhaust gas from the exit chamber back through the porous walls to dislodge and blow out the build-up of soot and ash on inner surfaces of the porous walls back through the first small flow entrance chamber.

27. The particulate trap system according to claim 26, wherein the means for creating the pressure difference between the exit chamber and the second small flow entrance chamber is a pressure relief valve operatively mounted to the exit chamber and for creating pressure build-up in the exit chamber, thereby forcing the filtered exhaust gas from the exit chamber back through the porous walls to dislodge and blow out the build-up of soot and ash on the inner surfaces of the porous walls back through the first small flow entrance chamber.

28. The particulate trap system according to claim 26, wherein the means for creating the pressure difference between the exit chamber and the second small flow entrance chamber is a venturi operatively mounted to the exit chamber and operatively connected to the second small flow entrance chamber, wherein the venturi increases pressure in the exit chamber and creates a suction in the second small flow entrance chamber, thereby forcing the filtered exhaust gas from the exit chamber back through the porous walls to dislodge and blow out the build-up of soot and ash on the inner surfaces of the porous walls back through the first small flow entrance chamber.

29. The particulate trap system according to claim 26, wherein the means for creating the pressure difference between the exit chamber and the second small flow entrance chamber is a venturi operatively mounted to the exit chamber and operatively connected to the secondary filter, wherein the venturi increases pressure in the exit chamber and creates a suction in the

second small flow entrance chamber, thereby forcing the filtered exhaust gas from the exit chamber back through the porous walls to dislodge and blow out the build-up of soot and ash on the inner surfaces of the porous walls back through the first small flow entrance chamber.

30. The particulate trap system according to claim 26, wherein the means for creating the pressure difference between the exit chamber and the second small flow entrance chamber is a pressure relief valve operatively mounted to the exit chamber and for creating a pressure build-up in the second small flow entrance chamber, and a venturi operatively mounted to the exit chamber and operatively connected to the second small flow entrance chamber, wherein the venturi increases pressure in the exit chamber and creates a suction in the second small flow entrance chamber, thereby forcing the filtered exhaust gas from the exit chamber back through the porous walls to dislodge and blow out the build-up of soot and ash on inner surfaces of the porous walls.

31. The particulate trap system according to claim 25, wherein the apertures of one of the cylindrical valves is aligned with the tube apertures of one of the tubes between the first small flow entrance chamber and the second small flow entrance chamber to allow exhaust gas to pass to one of the particulate trap modules for filtering through the porous walls, and the apertures of the remaining cylindrical valves are aligned with the tube apertures of the remaining tubes between the first large flow entrance chamber and the second large flow entrance chamber to allow exhaust gas to pass to the remaining particulate trap modules for filtering through the porous walls, and wherein the exhaust gas passes from the particulate trap modules into the exit chamber for release into the atmosphere.

34. The particulate trap system according to claim 33, further including:

means for actuating the poppet valve from the first position to the second position and from the second position to the first position, wherein one of the poppet valves is moved into the second position for receiving filtered exhaust gas back flow through the porous walls from the exit chamber; and

means for sequentially dislodging and blowing out the build-up of soot and ash for each of the at least one particulate trap modules in response to the pre-established engine operating condition, wherein one of the at least one particulate trap modules receives the back flow of exhaust gas from the exit chamber.

35. The particulate trap system according to claim 34, further including:

means for creating a pressure difference between the exit chamber and the second small flow entrance chamber in response to a pre-established engine operating condition, wherein the pressure in the exit chamber is greater than the pressure in the second small flow entrance chamber, thereby forcing the filtered exhaust gas from the exit chamber back through the porous walls to dislodge and blow out the build-up of soot and ash on inner surfaces of the porous walls back through the first small flow entrance chamber.

36. The particulate trap system according to claim 34, wherein the means for creating the pressure difference between the exit chamber and the second small flow entrance chamber is a pressure relief valve operatively mounted to the exit chamber and for creating pressure build-up in the exit chamber, thereby forcing the filtered exhaust gas from the exit chamber back through the porous walls to dislodge and blow out the build-up of soot and

ash on the inner surfaces of the porous walls back through the first small flow entrance chamber.

37. The particulate trap system according to claim 34, wherein the means for creating the pressure difference between the exit chamber and the second small flow entrance chamber is a venturi operatively mounted to the exit chamber and operatively connected to the second small flow entrance chamber, wherein the venturi increases pressure in the exit chamber and creates a suction in the second small flow entrance chamber, thereby forcing the filtered exhaust gas from the exit chamber back through the porous walls to dislodge and blow out the build-up of soot and ash on the inner surfaces of the porous walls back through the first small flow entrance chamber.

38. The particulate trap system according to claim 34, wherein the means for creating the pressure difference between the exit chamber and the second small flow entrance chamber is a pressure relief valve operatively mounted to the exit chamber and for creating a pressure build-up in the second small flow entrance chamber, and a venturi operatively mounted to the exit chamber and operatively connected to the second small flow entrance chamber, wherein the venturi increases pressure in the exit chamber and reduces pressure in the second small flow entrance chamber, thereby forcing the filtered exhaust gas from the exit chamber back through the porous walls to dislodge and blow out the build-up of soot and ash on inner surfaces of the porous walls.

39. A particulate trap system for an internal combustion engine having a nitrogen oxide (NOx) reduction aftertreatment system, comprising:

at least one particulate trap module to accept engine exhaust gas including a plurality of passages having porous walls for filtering exhaust gas,

oxidizing the particulate via the precious metal catalysts at an acceptable temperature range;

converting NOx to NO_2 in the plurality of passages via the precious metal catalyst;

storing the NO_2 in the NOx adsorber material;

adding fuel to a minority flow of the exhaust gas to convert it to a rich mixture; and

passing the minority flow of exhaust gas through a minority of the plurality of passages, thereby causing the rich mixture of exhaust gas flow to release stored NO_2 for reduction by CO in the rich mixture flow of exhaust gas in the presence of precious metal catalyst at the acceptable temperature range forming CO_2 and N_2.

61. The method for reducing nitrogen oxide (NOx) in a cross flow particulate trap system used with an internal combustion engine according to claim 39, further including the steps of:

aligning a first, normal lean exhaust gas entrance chamber with a first end of the through flow passages;

aligning a second, rich exhaust entrance chamber with a second end of the through flow passages;

filtering exhaust gas through the porous walls of the through flow passages;

collecting the filtered exhaust gas in a third, exit chamber;

directing the exhaust gas from the third, exit chamber to the atmosphere;

admitting a majority of the normal lean exhaust gas from the first normal lean exhaust chamber into the first end of the through flow passages for a period of time, and blocking a minority of the normal lean exhaust gas

from the first normal lean exhaust chamber into the first end of the through flow passages for a majority of the time;

admitting a minority rich exhaust gas from the second rich exhaust chamber into the second end of the through flow passages for a period of time;

blocking a majority of rich exhaust gas from the second rich exhaust chamber into the second end of said through flow passages for a minority of the time;

controlling the at least one first valve to allow normal lean exhaust gas to enter the first end of the majority of passages having porous walls, while precluding the rich exhaust gas from entering second end of the majority of passages;

allowing rich exhaust gas into the second ends of the minority of passages, while precluding the normal lean exhaust gas from entering the first ends of the minority of the passages; and

sequentially changing the passages receiving the normal lean exhaust gas and the rich exhaust gas flow.

62. The method for reducing nitrogen oxide (NOx) in a particulate trap system used with an internal combustion engine according to claim 39, further including the steps of:

treating the entering exhaust gas upstream of the particulate trap system;

cooling the exhaust gas stream when a maximum temperature is exceeded;

directing the majority of the exhaust gas flow to the particulate trap system to be admitted to the passages as normal lean exhaust;

directing and controlling the minority of the exhaust gas flow to an enrichment device;

injecting fuel into the minority exhaust flow stream;

igniting the injected fuel;

sensing the oxygen level downstream of the fuel injector;

monitoring and controlling at a stoichiometric to slightly rich mixture;

monitoring and controlling the temperature of the minority exhaust gas stream via the amount of fuel injected; and

directing the enriched minority exhaust flow to the passages as rich exhaust gas to the particulate trap system.

63. The method for reducing nitrogen oxide (NOx) in a particulate trap system having the at least one wall flow particulate trap used with an internal combustion engine according to claim 39, further including the steps of:

forcing exhaust gas through the porous walls coated with precious metal catalysts and NOx adsorber material of the wall flow particulate trap module;

directing a majority flow of lean exhaust gas from the engine to the vicinity of the at least one wall flow particulate trap module;

directing a minority flow of exhaust gas to the vicinity of the at least one wall flow particulate trap module;

collecting the filtered and purified exhaust gas from the at least one wall flow particulate trap module and releasing it to the atmosphere;

connecting the entrance end of the at least one wall flow particulate trap module to the first channel to admit lean exhaust gas;

connecting the entrance end of the at least one wall flow particulate trap module to the first channel to admit rich exhaust gas; and

sequentially changing the passages receiving the lean exhaust gas and the rich exhaust gas flow.

64. A method for filtering and regenerating particulate trap system for an internal combustion engine, comprising:

positioning an at least one particulate trap module to accept engine exhaust gas, wherein the at least one particulate trap module has a plurality of passages having porous walls for receiving the exhaust gas;

filtering the exhaust gas via the porous walls; and

periodically reversing a portion of the filtered exhaust gas back through the porous walls in reverse flow at sufficient pressure drop and resultant flow velocity to dislodge and erode any build-up of soot and ash from the porous walls.

65. The method for filtering and regenerating particulate trap system for an internal combustion engine according to claim 64, further including the steps of:

creating a pressure difference between the separation chamber and the exit chamber in response to a pre-established engine operating condition, wherein the pressure in the exit chamber is greater than the pressure in the separation chamber, thereby forcing the filtered exhaust gas from the exit chamber back through the porous walls to dislodge and blow out the build-up of soot and ash on inner surfaces of the porous walls.

66. A method for filtering and regenerating a particulate trap system for an internal combustion engine having a nitrogen oxide (NOx) reduction aftertreatment system, comprising:

accepting engine exhaust gas via an at least one particulate trap module having a plurality of passages having porous walls for filtering exhaust gas, wherein the passages have porous walls with inner surfaces coated with precious metal catalysts and NOx adsorber material;

passing a majority of lean exhaust gas through the porous walls of a majority of the plurality of passages;

removing the particulate via the porous walls and oxidizing the particulate via the precious metal catalysts at an acceptable temperature range;

converting NOx to NO_2 in the plurality of passages via the precious metal catalyst at an acceptable temperature range;

storing the NO_2 in the NOx adsorber material at the acceptable temperature range; and

adding fuel to a minority flow of the exhaust gas to convert it to a rich mixture and for passing the minority flow of exhaust gas through a minority of the plurality of passages, thereby causing the rich mixture of exhaust gas flow to release the stored NO_2 for reduction by CO in the rich mixture flow of exhaust gas in the presence of precious metal catalyst at the acceptable temperature range forming CO_2 and N_2.

AMENDED CLAIMS

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What is claimed is:

1. A particulate trap system for an internal combustion engine, comprising:

at least one particulate trap module positioned to accept engine exhaust gas including a plurality of passages having porous walls for receiving the exhaust gas, wherein the porous walls filter particulate from the exhaust gas; and

reversing means for periodically reversing a portion of the filtered exhaust gas back through the porous walls in reverse flow at a substantially constant pressure drop, resultant flow velocity, and duration sufficient to dislodge and erode any build-up of soot and ash from the porous walls.

2. The particulate trap system according to claim 1, wherein the at least one particulate trap module is at least one monolithic cross flow trap module having a plurality of through flow passages.

3. The particulate trap system according to claim 1, wherein the at least one particulate trap module is at least one wall flow trap module.

4. The particulate trap system according to claim 2, further including:

an entrance chamber for receiving the exhaust gas from the engine and operatively connected to a first side of the at least one particulate trap module;

a separation chamber operatively attached to a second side of the at least one particulate trap module and for receiving some of the exhaust gas from the at least one particulate trap module; and

an exit chamber for receiving the filtered exhaust gas passing through the porous walls of the at least one particulate trap.

5. The particulate trap system according to claim 4, further including:

means for creating a pressure difference between the separation chamber and the exit chamber in response to a pre-established engine operating condition, wherein the pressure in the exit chamber is greater than the pressure in the separation chamber, thereby forcing the filtered exhaust gas from the exit chamber back through the porous walls to dislodge and blow out the build-up of soot and ash on inner surfaces of the porous walls.

6. The particulate trap system according to claim 5, wherein the means for creating the pressure difference between the separation chamber and the exit chamber is a pressure relief valve associated with the exit chamber for creating pressure build-up in the exit chamber, thereby forcing the filtered exhaust gas from the exit chamber back through the porous walls to dislodge and blow out the build-up of soot and ash on the inner surfaces of the porous walls.

7. The particulate trap system according to claim 5, wherein the means for creating the pressure difference between the separation chamber and the exit chamber is a venturi associated with the exit chamber and operatively connected to the separation chamber, wherein the venturi increases pressure in the exit chamber and reduces the pressure in the

separation chamber, thereby forcing the filtered exhaust gas from the exit chamber back through the porous walls to dislodge and blow out the build-up of soot and ash on the inner surfaces of the porous walls.

8. The particulate trap system according to claim 5, wherein the means for creating the pressure difference between the separation chamber and the exit chamber is a pressure relief valve associated with the exit chamber valve for creating pressure build-up in the exit chamber, and a venturi associated with the exit chamber and operatively connected to the separation chamber, wherein the venturi increases pressure in the exit chamber and reduces the pressure in the separation chamber, thereby forcing the filtered exhaust gas from the exit chamber back through the porous walls to dislodge and blow out the build-up of soot and ash on the inner surfaces of the porous walls.

9. The particulate trap system according to claim 5, further including at least one exit valve to selectively allow exhaust gas to flow through the through flow passages to blow out the removed soot and ash and to erode any additional soot and ash.

10. The particulate trap system according to claim 9, further including:

an igniter for burning the soot; and

a chamber for storing the ash.

11. The particulate trap system according to claim 5, further including:

a plurality of valves wherein at least one valve precludes exhaust gas from entering the at least one particulate trap module from the entrance chamber and at least one valve of the same particulate trap module allows exhaust gas to flow from the through passages to the separation chamber for periodically allowing the filtered exhaust gas from the exit chamber to flow back through the porous walls of the through flow passages to blow out the build-up of soot and ash on inner surfaces of the porous walls;

wherein the remaining valves allow exhaust gas to enter the remaining particulate trap modules from the entrance chamber and preclude the exhaust gas from exiting the remaining particulate trap modules to the separation chamber, thereby causing the exhaust gas to be filtered through the porous walls; and

wherein each of the particulate trap modules is sequentially precluded from receiving exhaust gas from the entrance chamber via one of the valves and at least one valve of the same particulate trap module allows exhaust gas to flow from the through passages to the separation chamber to sequentially allow filtered exhaust gas from the exit chamber to flow back through the porous walls of the through flow passages to blow out the build-up of soot and ash on the inner surfaces of the porous walls.

12. The particulate trap system according to claim 11, wherein the at least one particulate trap module being precluded from receiving exhaust gas from the entrance chamber is allowed to receive exhaust gas through flow via the opening of the at least one valve to remove the blown out soot and ash.

13. The particulate trap system according to claim 11, further including:

an igniter for burning the soot; and

a chamber for storing the ash.

14. The particulate trap system according to claim 5, further including:

a pressure relief valve operatively mounted to the exit chamber and for creating pressure build-up in the exit chamber prior to the filtered exhaust gas exiting to the atmosphere;

a plurality of valves precluding exhaust gas from exiting the particulate trap modules into the separation chamber;

wherein at least one valve allows exhaust gas to enter the separation chamber from the at least one particulate trap module in response to a pre-established engine operating condition, thereby allowing the filtered exhaust gas from the exit chamber to flow back through the through flow passages of said at least one particulate trap module to blow out the build-up of soot and ash on the inner surfaces of the porous walls;

wherein the remaining valves preclude the exhaust gas from exiting the remaining particulate trap modules to the separation chamber in response to the pre-established engine operating condition, thereby filtering the exhaust gas through the porous walls;

wherein the particulate trap module receiving the filtered exhaust gas via back flow simultaneously receives a high velocity of exhaust gas through flow from the entrance chamber to the separation chamber to erode and blow out the soot and ash; and

wherein each of the particulate trap modules is sequentially allowed to pass exhaust gas to the separation chamber from the entrance chamber, thereby sequentially allowing filtered exhaust gas from the exit chamber to flow back through the porous walls of the through flow passages to blow out

the build-up of soot and ash on the inner surfaces of the porous walls of each of the at least one particulate trap modules in sequence.

15. The particulate trap system according to claim 11, wherein the plurality of valves are perforated slide valves, each of the perforated slide valves include a stationary perforated plate and a moveable perforated plate, wherein the stationary and the moveable perforated plates have apertures therein;

means for moving the moveable perforated plate over the stationary perforated plate so that the apertures are in alignment to allow exhaust gas to pass; and

means for moving the moveable perforated plate over the stationary perforated plate so that the apertures are not in alignment to preclude exhaust gas from passing.

16. The particulate trap system according to claim 14, wherein the plurality of valves are perforated slide valves, each of the perforated slide valves include a stationary perforated plate and a moveable perforated plate, wherein the stationary and the moveable perforated plates have apertures therein;

means for moving the moveable perforated plate over the stationary perforated plate so that the apertures are in alignment to allow exhaust gas to pass; and

means for moving the moveable perforated plate over the stationary perforated plate so that the apertures are not in alignment to preclude exhaust gas from passing.

17. The particulate trap system according to claim 11, wherein the plurality of valves are poppet valves;

means for moving the poppet valves away from the particulate trap modules to allow exhaust gas to pass into the through flow passages; and

means for moving the poppet valves toward the particulate trap modules to preclude exhaust gas from passing into the through flow passages.

18. The particulate trap system according to claim 14, wherein the plurality of valves are poppet valves;

means for moving the poppet valves away from the particulate trap modules to allow exhaust gas to pass into the through flow passages; and

means for moving the poppet valves toward the particulate trap modules to preclude exhaust gas from passing into the through flow passages.

19. The particulate trap system according to claim 5, further including:

a first rotary valve having a strut;

means for rotating the strut of the rotary valve around a single particulate trap module between the entrance chamber and the through flow passages for precluding exhaust gas from passing from the entrance chamber to some of the through flow passages;

a second rotary valve having an aperture and face plate and rotatably mounted to the single particulate trap module between the through flow passages and the separation chamber, wherein exhaust gas is allowed to flow through the aperture to the separation chamber and precluded via the face plate from flowing from the through flow passages to the separation chamber;

means for synchronizing the rotation of the first rotary valve and the second rotary valve;

wherein the through flow passages receiving exhaust gas from the entrance chamber that are plugged by the face plate of the second rotary valve filter the exhaust gas through the porous walls;

wherein the though flow passages being blocked by the strut of the first rotary valve and plugged by the face plate of the second rotary valve;

wherein the through flow passages are blocked by the strut and open to the separation chamber via the aperture receive a back flow of filtered exhaust gas through the porous walls from the exit chamber to blow out the build-up of soot and ash on the inner surfaces of the porous walls;

wherein some of the exhaust gas that passes through the through flow passages at a velocity sufficient to erode and dislodge ash and soot build-up from the entrance chamber and into the separation chamber via the aperture is filtered via a secondary filter;

wherein when the means for creating a pressure difference between the separation chamber and the exit chamber in response to the pre-established engine operating condition is started and the pressure in the exit chamber will be greater than the pressure in the separation chamber, thereby forcing the filtered exhaust gas from the exit chamber back through the through flow passages of the porous walls open via the aperture to the separation chamber to dislodge and blow out the build-up of soot and ash on inner surfaces of the porous walls; and

wherein each of the through flow passages are sequentially precluded from receiving exhaust gas from the entrance chamber via the strut of the first rotary valve and allowed to pass exhaust gas to the separation chamber when the separation chamber via the aperture filtered exhaust gas from the exit chamber flows back through the porous walls of through flow passages to

blow out the build-up of soot and ash on the inner surfaces of the porous walls.

20. The particulate trap system according to claim 5, further including:

a sole rotary valve having an aperture and face plate and rotatably mounted to a single particulate trap module between the through flow passages and the separation chamber, wherein exhaust gas is allowed to flow through the aperture to the separation chamber and precluded from flowing from the through flow passages to the separation chamber via the face plate;

means for rotating the sole rotary valve;

wherein the exhaust gas entering the through flow passages plugged by the face plate is filtered through the porous walls;

wherein when the means for creating a pressure difference between the separation chamber and the exit chamber in response to the pre-established engine operating condition is started and the pressure in the exit chamber will be greater than the pressure in the separation chamber, thereby forcing the filtered exhaust gas from the exit chamber back through the through flow passages of the porous walls open via the aperture to the separation chamber to dislodge and blow out the build-up of soot and ash on inner surfaces of the porous walls while simultaneously receiving a high velocity of exhaust gas through flow from the entrance chamber to the separation chamber to erode and blow out the soot and ash; and

wherein the exhaust gas entering the through flow passages and exiting into the separation chamber via the aperture is filtered through a secondary filter.

21. The particulate trap system according to claim 5, further including:

a secondary filter operatively connected to the separation chamber for filtering exhaust gas in the separation chamber before release into the atmosphere; and

a remote energized three-way rotary valve operatively connected to the separation chamber and operatively connected to a high pressure source for supplying a burst of high pressure air to the secondary filter in reverse flow to dislodge any build-up of soot and ash on the secondary filter in response to the pre-established engine operating condition.

22. The particulate trap system according to claim 21 wherein the secondary filter is porous ceramic.

23. The particulate trap system according to claim 5, further including:

a refractory fabric secondary filter having a convoluted perforated metal support plate operatively positioned to receive the exhaust gas exiting the through flow passages to the separation chamber and for filtering the exhaust gas in the separation chamber before release into the atmosphere, wherein the convoluted perforated support metal plate limits the flexing of the refractory fabric secondary filter and allows some flexing to break up accumulated soot and ash; and

an exit passage operatively connected subsequent to the secondary filter of the separation chamber for directing the filtered exhaust gas passing though the secondary filter to the atmosphere.

24. The particulate trap system according to claim 3, further including:

a first small flow entrance chamber for receiving some of the exhaust gas from the engine and operatively connected to one of the at least one particulate trap module;

a first large flow entrance chamber for receiving the remainder of exhaust gas from the engine and operatively connected to the remaining at least one particulate trap module;

plurality of moveable cylindrical slide valves, each valve including an inner perforated cylinder having apertures to allow exhaust gas to pass when aligned with tube apertures in outer tubes and to preclude exhaust gas from flowing through the apertures and the tube apertures when not aligned;

an exit chamber operatively attached to the at least one particulate trap module and for receiving the filtered exhaust gas from the at least one particulate trap module and releasing the filtered exhaust gas into the atmosphere;

a second small flow entrance chamber for receiving the exhaust gas passing from the first small flow entrance chamber through the cylindrical slide valves, wherein the exhaust gas is filtered through the porous walls of the wall flow passages and directed to the exit chamber;

a second large flow entrance chamber for receiving the exhaust gas from the first large flow entrance chamber through the cylindrical slide valves, wherein the exhaust gas is filtered through the porous walls of the wall flow passages and directed to the exit chamber; and

a separation chamber operatively connected to the first small flow chamber for receiving a back flow of filtered exhaust gas.

25. The particulate trap system according to claim 24, further including:

a three-way valve operatively mounted to the first small flow entrance chamber;

wherein the three-way valve blocks the exhaust gas entering the first small flow entrance chamber and simultaneously opens a connection between the first small entrance chamber and the separation chamber, and thereby causing the exhaust gas to enter the first large flow entrance chamber in response to a pre-established engine operating condition, thereby creating the pressure difference between the exit chamber and the second small flow entrance chamber, wherein the pressure in the exit chamber is greater than the pressure in the second small flow entrance chamber, thereby forcing the filtered exhaust gas from the exit chamber back through the porous walls to dislodge and blow out the build-up of soot and ash on inner surfaces of the porous walls into the secondary filter for filtering of the dislodged and blown out soot and ash; and

wherein the apertures of one of the cylindrical valves is adjusted out of alignment with the tube apertures of one of the outside tubes between the first small flow entrance chamber and the second small flow entrance chamber to preclude exhaust gas from passing to one of the particulate trap modules in response to the pre-established engine operating condition.

26. The particulate trap system according to claim 24, further including:

means for creating a pressure difference between the exit chamber and the second small flow entrance chamber in response to a pre-established engine operating condition, wherein the pressure in the exit chamber is greater

the filtered exhaust gas from the exit chamber back through the porous walls to dislodge and blow out the build-up of soot and ash on inner surfaces of the porous walls back through the first small flow entrance chamber.

27. The particulate trap system according to claim 26, wherein the means for creating the pressure difference between the exit chamber and the second small flow entrance chamber is a pressure relief valve associated with the exit chamber and for creating pressure build-up in the exit chamber, thereby forcing the filtered exhaust gas from the exit chamber back through the porous walls to dislodge and blow out the build-up of soot and ash on the inner surfaces of the porous walls back through the first small flow entrance chamber.

28. The particulate trap system according to claim 26, wherein the means for creating the pressure difference between the exit chamber and the second small flow entrance chamber is a venturi associated with the exit chamber and operatively connected to the second small flow entrance chamber, wherein the venturi increases pressure in the exit chamber and creates a suction in the second small flow entrance chamber, thereby forcing the filtered exhaust gas from the exit chamber back through the porous walls to dislodge and blow out the build-up of soot and ash on the inner surfaces of the porous walls back through the first small flow entrance chamber.

29. The particulate trap system according to claim 26, wherein the means for creating the pressure difference between the exit chamber and the second small flow entrance chamber is a venturi associated with the exit chamber and operatively connected to the secondary filter, wherein the venturi increases pressure in the exit chamber and creates a suction in the

second small flow entrance chamber, thereby forcing the filtered exhaust gas from the exit chamber back through the porous walls to dislodge and blow out the build-up of soot and ash on the inner surfaces of the porous walls back through the first small flow entrance chamber.

30. The particulate trap system according to claim 26, wherein the means for creating the pressure difference between the exit chamber and the second small flow entrance chamber is a pressure relief valve associated with the exit chamber and for creating a pressure build-up in the second small flow entrance chamber, and a venturi associated with the exit chamber and operatively connected to the second small flow entrance chamber, wherein the venturi increases pressure in the exit chamber and creates a suction in the second small flow entrance chamber, thereby forcing the filtered exhaust gas from the exit chamber back through the porous walls to dislodge and blow out the build-up of soot and ash on inner surfaces of the porous walls.

31. The particulate trap system according to claim 25, wherein the apertures of one of the cylindrical valves is aligned with the tube apertures of one of the tubes between the first small flow entrance chamber and the second small flow entrance chamber to allow exhaust gas to pass to one of the particulate trap modules for filtering through the porous walls, and the apertures of the remaining cylindrical valves are aligned with the tube apertures of the remaining tubes between the first large flow entrance chamber and the second large flow entrance chamber to allow exhaust gas to pass to the remaining particulate trap modules for filtering through the porous walls, and wherein the exhaust gas passes from the particulate trap modules into the exit chamber for release into the atmosphere.

32. The particulate trap system according to claim 31, further including:

means for sequentially dislodging and blowing out the build-up of soot and ash for each of the at least one particulate traps in response to the pre-established engine operating condition.

33. The particulate trap system according to claim 3, further including:

a first small flow entrance chamber for receiving some of the exhaust gas from the engine and operatively connected to one of the at least one particulate trap module;

a first large flow entrance chamber for receiving the remainder of exhaust gas from the engine and operatively connected to the remaining at least one particulate trap module;

a plurality of poppet valves, each valve having a first position and a second position, wherein in the first position exhaust gas is allowed to pass from the first large entrance chamber to the through the porous walls for filtering to the exit chamber, and wherein in the second position filtered exhaust gas from the exit chamber is forced back through the porous walls to the first small flow chamber to dislodge and blow out ash and soot build-up on the inner surfaces of the porous walls;

an exit chamber operatively attached to the at least one particulate trap module and for receiving the filtered exhaust gas from the at least one particulate trap module and releasing the filtered exhaust gas into the atmosphere;

a separation chamber operatively connected to the first small flow chamber for receiving a back flow of filtered exhaust gas.

34. The particulate trap system according to claim 33, further including:

means for actuating the poppet valve from the first position to the second position and from the second position to the first position, wherein one of the poppet valves is moved into the second position for receiving filtered exhaust gas back flow through the porous walls from the exit chamber; and

means for sequentially dislodging and blowing out the build-up of soot and ash for each of the at least one particulate trap modules in response to the pre-established engine operating condition, wherein one of the at least one particulate trap modules receives the back flow of exhaust gas from the exit chamber.

35. The particulate trap system according to claim 34, further including:

means for creating a pressure difference between the exit chamber and the second small flow entrance chamber in response to a pre-established engine operating condition, wherein the pressure in the exit chamber is greater than the pressure in the second small flow entrance chamber, thereby forcing the filtered exhaust gas from the exit chamber back through the porous walls to dislodge and blow out the build-up of soot and ash on inner surfaces of the porous walls back through the first small flow entrance chamber.

36. The particulate trap system according to claim 35, wherein the means for creating the pressure difference between the exit chamber and the second small flow entrance chamber is a pressure relief valve associated with the exit chamber and for creating pressure build-up in the exit chamber, thereby forcing the filtered exhaust gas from the exit chamber back through the porous walls to dislodge and blow out the build-up of soot and

ash on the inner surfaces of the porous walls back through the first small flow entrance chamber.

37. The particulate trap system according to claim 35, wherein the means for creating the pressure difference between the exit chamber and the second small flow entrance chamber is a venturi associated with the exit chamber and operatively connected to the second small flow entrance chamber, wherein the venturi increases pressure in the exit chamber and creates a suction in the second small flow entrance chamber, thereby forcing the filtered exhaust gas from the exit chamber back through the porous walls to dislodge and blow out the build-up of soot and ash on the inner surfaces of the porous walls back through the first small flow entrance chamber.

38. The particulate trap system according to claim 35, wherein the means for creating the pressure difference between the exit chamber and the second small flow entrance chamber is a pressure relief valve associated with the exit chamber and for creating a pressure build-up in the second small flow entrance chamber, and a venturi associated with the exit chamber and operatively connected to the second small flow entrance chamber, wherein the venturi increases pressure in the exit chamber and reduces pressure in the second small flow entrance chamber, thereby forcing the filtered exhaust gas from the exit chamber back through the porous walls to dislodge and blow out the build-up of soot and ash on inner surfaces of the porous walls.

39. A particulate trap system for an internal combustion engine having a nitrogen oxide (NOx) reduction aftertreatment system, comprising:

at least one particulate trap module to accept engine exhaust gas including a plurality of passages having porous walls for filtering exhaust gas,

the porous walls having inner surfaces coated with precious metal catalysts and NOx adsorber material;

means for passing a majority of lean exhaust gas through the porous walls of a majority of the plurality of passages, the porous walls removing particulate and oxidizing the particulate via the precious metal catalysts at an acceptable temperature range;

means for converting NOx to NO_2 in the plurality of passages via the precious metal catalyst at the acceptable temperature range;

means for storing the NO_2 in the NOx adsorber material at the acceptable temperature range; and

means for adding fuel to a minority flow of the exhaust gas to convert it to a rich mixture and for passing the minority flow of exhaust gas through a minority of the plurality of passages, thereby causing the rich mixture of exhaust gas flow to release the stored NO_2 for reduction by CO in the rich mixture flow of exhaust gas in the presence of precious metal catalyst at the acceptable temperature range forming CO_2 and N_2.

40. The particulate trap system for an internal combustion engine having a nitrogen oxide (NOx) reduction aftertreatment system according to claim 39, wherein the at least one particulate trap module is an at least one cross flow particulate trap module having a plurality of through flow passages having the porous walls, the porous walls having inner surfaces coated with precious metal catalysts and NOx adsorber material;

a first, normal lean exhaust gas entrance chamber that registers with a first end of the through flow passages;

a second, rich exhaust entrance chamber that registers with a second end of the through flow passages;

a third, exit chamber that surrounds the porous walls of the through flow passages for collecting the filtered exhaust gas and directing it to the atmosphere;

at least one first valve having a first position for admitting a majority of the normal lean exhaust gas from the first normal lean exhaust chamber into the first end of the through flow passages for a majority of the time, and a second position for blocking a minority of the normal lean exhaust gas from the first normal lean exhaust chamber into the first end of the through flow passages having porous walls for a majority of time;

at least one second valve having a first position for admitting a minority of rich exhaust gas from the second rich exhaust chamber into the second end of the through flow passages for a minority of time, and a second position for blocking a majority of rich exhaust gas from the second rich exhaust chamber into the second end of the through flow passages for a minority of time;

means for controlling the at least one first valve to allow lean exhaust gas to enter the first end of the majority of passages, while the at least one second valve precludes the rich exhaust gas from entering second end of the majority of passages;

second means for controlling the at least one second valve to allow rich exhaust gas into the second ends of the minority of passages, while the at least one first valve precludes the normal lean exhaust gas from entering the first ends of the minority of the passages; and

means for actuating the at least one first valve and the at least one second valve to sequentially change the passages receiving the normal lean exhaust gas and the rich exhaust gas flow.

41. The particulate trap system having the NOx reduction system according to claim 40, wherein the minority of the flow is $1/6^{th}$ to $1/20^{th}$ and the majority of the flow is 5/6 to $19/20^{th}$ of the total exhaust flow from the engine.

42. The particulate trap system having the NOx reduction system according to claim 39, further including:

an exhaust gas treatment device upstream of the particulate trap system;

wherein the exhaust gas stream from the engine is cooled if a maximum temperature is exceeded;

a first duct to direct the majority of the exhaust gas flow to the particulate trap system to be admitted to the passages as normal lean exhaust;

a second duct to direct the minority of the exhaust gas flow to an enrichment device, wherein a control valve undergoing conditions controls the flow rate of the minority of exhaust gas flow;

a fuel injector to inject fuel into the minority exhaust flow stream;

an igniter and associated burner to provide combustion of the injected fuel;

an oxygen sensor downstream of the fuel injector and the burner and control system and closed loop injector control to assure the mixture burned is at a slightly rich mixture;

a second control system and a temperature sensor to monitor and control the temperature of the minority exhaust gas stream, by controlling the flow rate of the minority exhaust gas stream and through the amount of fuel injected to maintain the slightly rich condition; and

a third duct to direct the enriched minority exhaust flow to the passages as rich exhaust gas to the particulate trap system.

43. The particulate trap system for an internal combustion engine having a nitrogen oxide (NOx) reduction aftertreatment system according to claim 39, wherein the at least one particulate trap module is a wall flow particulate trap module having a plurality of passages having porous walls, wherein the opposite ends of alternate passages are plugged to force exhaust gas entering the passages at one end of the trap module to pass through the porous walls and then pass out through exit ends of the alternate passages at the other end of the trap module, said porous wall passages at entrance ends of the wall flow particulate trap module having coated of precious metal catalysts and a coating of NOx adsorber material;

a first channel for directing a majority flow of lean exhaust gas from the engine to the vicinity of the wall flow particulate trap;

a second channel for directing a minority flow of rich exhaust gas from the engine to the vicinity of the wall flow particulate trap;

a third channel for collecting the filtered and purified exhaust from the trap and releasing it to the atmosphere;

a three-way valve having a first position for connecting the entrance end of the wall flow particulate trap to the first channel to admit normal lean exhaust gas, and a second position for or to the second channel connecting the entrance end of the wall flow particulate trap to the first channel to admit rich exhaust gas; and

means for actuating the three-way valve to sequentially change the passages receiving the normal lean exhaust gas and the rich exhaust gas flow.

44. The particulate trap system for an internal combustion engine having a nitrogen oxide (NOx) reduction aftertreatment system according to

moveable perforated plate, wherein the stationary and the moveable perforated plates have apertures therein;

means for moving the moveable perforated plate over the stationary perforated plate so that the apertures are in alignment to allow exhaust gas to pass; and

means for moving the moveable perforated plate over the stationary perforated plate so that the apertures are not in alignment to preclude exhaust gas from passing.

45. The particulate trap system for an internal combustion engine having a nitrogen oxide (NOx) reduction aftertreatment system according to claim 43, wherein the plurality of valves are poppet valves;

means for moving the poppet valves away from the particulate trap modules to allow exhaust gas to pass into the through flow passages; and

means for moving the poppet valves toward the particulate trap modules to preclude exhaust gas from passing into the through flow passages.

46. The particulate trap system for an internal combustion engine having a nitrogen oxide (NOx) reduction aftertreatment system according to claim 39, wherein the acceptable temperature range is from 250 to 450°C.

47. The particulate trap system for an internal combustion engine having a nitrogen oxide (NOx) reduction aftertreatment system according to claim 39, further including means for regulating the temperature between 250 and 450°C.

48. The particulate trap system for an internal combustion engine having a nitrogen oxide (NOx) reduction aftertreatment system according to claim 39, further including:

a cooler for cooling the flow of exhaust gas cooler when the temperature exceeds 450°C by actuating a cooling valve for forcing a portion of the exhaust gas through the cooler; and

a flow valve for redirecting a greater portion of the exhaust gas to the rich exhaust gas flow chamber, thereby causing the injector to increase the fuel being injected to maintain the rich exhaust gas flow increasing the energy supplied to the at least one particulate trap module when the temperature is below 250°C.

49. The particulate trap system for an internal combustion engine having a nitrogen oxide (NOx) reduction aftertreatment system according to claim 42, further including:

means for periodically removing incombustible ash from the at least one cross flow particulate trap module in response to a pre-established engine operating condition;

wherein the means for periodically removing incombustible ash includes a flow valve for redirecting a greater portion of the exhaust gas to the rich exhaust gas flow chamber, thereby increasing the pressure significantly higher than in the lean exhaust gas chamber;

valves, wherein in one of the at least one particulate trap modules, the valves are open to the rich exhaust gas flow and the lean exhaust gas flow, thereby allowing a high velocity through flow to remove the ash;

means for separating and storing the ash; and

means for sequentially changing the at least one cross flow particulate trap module receiving the through flow until all of the at least one cross flow particulate traps receive the through flow.

50. The particulate trap system for an internal combustion engine having a nitrogen oxide (NOx) reduction aftertreatment system according to claim 49, wherein the means for separating and storing ash is an external chamber.

51. The particulate trap system for an internal combustion engine having a nitrogen oxide (NOx) reduction aftertreatment system according to claim 50, wherein the fuel injector is turned off during the removal of ash.

52. The particulate trap system for an internal combustion engine having a nitrogen oxide (NOx) reduction aftertreatment system according to claim 43, further including:

means for periodically removing incombustible ash from the at least one wall flow particulate trap module in response to a pre-established engine operating condition;

means for creating a pressure difference between the exit chamber and the second small flow entrance chamber in response to a pre-established engine operating condition, wherein the pressure in the exit chamber is greater than the pressure in the second small flow entrance chamber, thereby forcing the filtered exhaust gas from the exit chamber back through the porous walls to dislodge and blow out the build-up of soot and ash on inner surfaces of the porous walls back through the first small flow entrance chamber;

simultaneously opening the rich exhaust gas chamber to an ash separator and storage container; and

means for sequentially changing the at least one wall flow particulate trap module receiving the through flow until all of the at least one wall flow particulate traps receive the reverse flow.

53. The particulate trap system for an internal combustion engine having a nitrogen oxide (NOx) reduction aftertreatment system according to claim 52, further including:

an external chamber for storing the incombustible ash from the at least one cross particulate trap module.

54. The particulate trap system for an internal combustion engine having a nitrogen oxide (NOx) reduction aftertreatment system according to claim 53, further including a secondary filter at the ash separator and storage container.

55. The particulate trap system for an internal combustion engine having a nitrogen oxide (NOx) reduction aftertreatment system according to claim 53, wherein the means for creating the pressure difference between the exit chamber and the second small flow entrance chamber is a pressure relief valve operatively mounted to the exit chamber and for creating pressure build-up in the exit chamber, thereby forcing the filtered exhaust gas from the exit chamber back through the porous walls to dislodge and blow out the build-up of soot and ash on the inner surfaces of the porous walls back through the first small flow entrance chamber.

56. The particulate trap system for an internal combustion engine having a nitrogen oxide (NOx) reduction aftertreatment system according to claim 53, wherein the means for creating the pressure difference between the exit chamber and the second small flow entrance chamber is a venturi operatively mounted to the exit chamber and operatively connected to the second small flow entrance chamber, wherein the venturi increases pressure in the exit chamber and creates a suction in the second small flow entrance chamber, thereby forcing the filtered exhaust gas from the exit chamber back through the porous walls to dislodge and blow out the build-up of soot and ash on the inner surfaces of the porous walls back through the first small flow entrance chamber.

57. The particulate trap system for an internal combustion engine having a nitrogen oxide (NOx) reduction aftertreatment system according to claim 52, wherein the means for creating the pressure difference between the exit chamber and the second small flow entrance chamber is a pressure relief valve operatively mounted to the exit chamber and for creating a pressure build-up in the second small flow entrance chamber, and a venturi operatively mounted to the exit chamber and operatively connected to the second small flow entrance chamber, wherein the venturi increases pressure in the exit chamber and reduces pressure in the second small flow entrance chamber, thereby forcing the filtered exhaust gas from the exit chamber back through the porous walls to dislodge and blow out the build-up of soot and ash on inner surfaces of the porous walls.

58. The particulate trap system for an internal combustion engine having a nitrogen oxide (NOx) reduction aftertreatment system according to

means for determining when the particulate trap module having adsorber-catalyst is contaminated with sulfur;

means for regenerating and decontaminating the particulate trap system by maintaining it at substantially 700°C via a cool valve to cool the exhaust gas stream and a flow valve to direct a greater portion of the exhaust gas into the rich flow stream, thereby increasing the injected fuel while maintaining a stoichiometric mixture;

means for passing the rich mixture through each of the particulate trap module at an increased duration than from normal operations; and

wherein sulfur contamination in the presence of catalyst and hydrocarbons converts sulfur contamination to H_2S and H_2S is released to the atmosphere.

59. The particulate trap system for an internal combustion engine having a nitrogen oxide (NOx) reduction aftertreatment system according to claim 39, further including:

means to periodically reduce the flow of the rich mixture through the passages for NO removal with minimum fuel expended under various engine operating conditions.

60. A method for reducing nitrogen oxide (NOx) in a particulate trap system used with an internal combustion engine, the steps comprising:

accepting exhaust gas to at least one particulate trap module including a plurality of passages having porous walls;

passing a majority of lean exhaust gas through a majority of the plurality of passages having the porous walls,

filtering and removing particulate from the exhaust gas through the

oxidizing the particulate via the precious metal catalysts at an acceptable temperature range;

converting NOx to NO_2 in the plurality of passages via the precious metal catalyst;

storing the NO_2 in the NOx adsorber material;

adding fuel to a minority flow of the exhaust gas to convert it to a rich mixture; and

passing the minority flow of exhaust gas through a minority of the plurality of passages, thereby causing the rich mixture of exhaust gas flow to release stored NO_2 for reduction by CO in the rich mixture flow of exhaust gas in the presence of precious metal catalyst at the acceptable temperature range forming CO_2 and N_2.

61. The method for reducing nitrogen oxide (NOx) in a cross flow particulate trap system used with an internal combustion engine according to claim 60, further including the steps of:

aligning a first, normal lean exhaust gas entrance chamber with a first end of the through flow passages;

aligning a second, rich exhaust entrance chamber with a second end of the through flow passages;

filtering exhaust gas through the porous walls of the through flow passages;

collecting the filtered exhaust gas in a third, exit chamber;

directing the exhaust gas from the third, exit chamber to the atmosphere;

admitting a majority of the normal lean exhaust gas from the first normal lean exhaust chamber into the first end of the through flow passages

from the first normal lean exhaust chamber into the first end of the through flow passages for a majority of the time;

admitting a minority of rich exhaust gas from the second rich exhaust chamber into the second end of the through flow passages for a period of time;

blocking a majority of rich exhaust gas from the second rich exhaust chamber into the second end of said through flow passages for a minority of the time;

controlling the at least one first valve to allow normal lean exhaust gas to enter the first end of the majority of passages having porous walls, while precluding the rich exhaust gas from entering second end of the majority of passages;

allowing rich exhaust gas into the second ends of the minority of passages, while precluding the normal lean exhaust gas from entering the first ends of the minority of the passages; and

sequentially changing the passages receiving the normal lean exhaust gas and the rich exhaust gas flow.

62. The method for reducing nitrogen oxide (NOx) in a particulate trap system used with an internal combustion engine according to claim 60, further including the steps of:

treating the entering exhaust gas upstream of the particulate trap system;

cooling the exhaust gas stream when a maximum temperature is exceeded;

directing the majority of the exhaust gas flow to the particulate trap system to be admitted to the passages as normal lean exhaust;

injecting fuel into the minority exhaust flow stream;

igniting the injected fuel;

sensing the oxygen level downstream of the fuel injector;

monitoring and controlling at a stoichiometric to slightly rich mixture;

monitoring and controlling the temperature of the minority exhaust gas stream via the amount of fuel injected; and

directing the enriched minority exhaust flow to the passages as rich exhaust gas to the particulate trap system.

63. The method for reducing nitrogen oxide (NOx) in a particulate trap system having the at least one wall flow particulate trap used with an internal combustion engine according to claim 60, further including the steps of:

forcing exhaust gas through the porous walls coated with precious metal catalysts and NOx adsorber material of the wall flow particulate trap module;

directing a majority flow of lean exhaust gas from the engine to the vicinity of the at least one wall flow particulate trap module;

directing a minority flow of exhaust gas to the vicinity of the at least one wall flow particulate trap module;

collecting the filtered and purified exhaust gas from the at least one wall flow particulate trap module and releasing it to the atmosphere;

connecting the entrance end of the at least one wall flow particulate trap module to the first channel to admit lean exhaust gas;

connecting the entrance end of the at least one wall flow particulate trap module to the first channel to admit rich exhaust gas; and

64. A method for filtering and regenerating particulate trap system for an internal combustion engine, comprising:

positioning an at least one particulate trap module to accept engine exhaust gas, wherein the at least one particulate trap module has a plurality of passages having porous walls for receiving the exhaust gas;

filtering the exhaust gas via the porous walls; and

periodically reversing a portion of the filtered exhaust gas back through the porous walls in reverse flow at a substantially constant pressure drop, resultant flow and duration sufficient to dislodge and erode any build-up of soot and ash from the porous walls.

65. The method for filtering and regenerating particulate trap system for an internal combustion engine according to claim 64, further including the steps of:

creating a pressure difference between the separation chamber and the exit chamber in response to a pre-established engine operating condition, wherein the pressure in the exit chamber is greater than the pressure in the separation chamber, thereby forcing the filtered exhaust gas from the exit chamber back through the porous walls to dislodge and blow out the build-up of soot and ash on inner surfaces of the porous walls.

66. A method for filtering and regenerating a particulate trap system for an internal combustion engine having a nitrogen oxide (NOx) reduction aftertreatment system, comprising:

accepting engine exhaust gas via an at least one particulate trap module having a plurality of passages having porous walls for filtering exhaust gas, wherein the passages have porous walls with inner surfaces coated with precious metal catalysts and NOx adsorber material;

passing a majority of lean exhaust gas through the porous walls of a majority of the plurality of passages;

removing the particulate via the porous walls and oxidizing the particulate via the precious metal catalysts at an acceptable temperature range;

converting NOx to NO_2 in the plurality of passages via the precious metal catalyst at an acceptable temperature range;

storing the NO_2 in the NOx adsorber material at the acceptable temperature range; and

adding fuel to a minority flow of the exhaust gas to convert it to a rich mixture and for passing the minority flow of exhaust gas through a minority of the plurality of passages, thereby causing the rich mixture of exhaust gas flow to release the stored NO_2 for reduction by CO in the rich mixture flow of exhaust gas in the presence of precious metal catalyst at the acceptable temperature range forming CO_2 and N_2.

67. The particulate trap system according to claim 3, further including:

rotary valve means for preventing exhaust gas entry into a minority of the passages and for connecting an entrance of the minority of the passages to a separation chamber, wherein the rotary valve rotates to sequentially cause reverse flow through the porous walls of each of the minority of the passages while permitting normal flow to continue through the porous walls of a majority of the trap passages.

68. The particulate trap system according to claim 39, wherein the means for passing a majority of lean exhaust gas through the porous of a majority of the plurality of passages includes rotary valve means for preventing exhaust gas entry into a minority of the passages and for connecting an entrance of the minority of the passages to a separation chamber, wherein the rotary valve rotates to sequentially cause reverse flow through the porous walls of each of the minority of the passages while permitting normal flow to continue through the porous walls of a majority of the trap passages.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US02/40107

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : B01D 46/00; F01N 3/00, 3/023, 3/033, 3/36
US CL : 55/284, 302, 303, 385.3, 428.1, 523, DIG.10, DIG.30; 60/274, 295, 296, 297, 299, 303, 311

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : Please See Continuation Sheet

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6,233,926 B1 (BAILEY et al) 22 May 2001 (22.05.2001), Figures 1-12 and column 1, line 5 to column 20, line 50.	1, 2, 4, 64, and 65
X — Y	US 5,930,995 A (WATANABE et al) 03 August 1999 (03.08.1999), Figures 1-10 and column 1, line 4 to column 8, line 22.	1, 3, 64, and 65 ---------- 2
X — Y	JP 4-31613 (NISSAN MOTOR CO LTD) 03 February 1992 (03.02.1992), Figure 1.	1, 3, 64, and 65 ---------- 2
Y	US 4,833,883 A (ODA et al) 30 May 1989 (30.05.1989), Figures 1-3 and column 1, lines 20-38.	2
A	US 6,314,722 B1 (MATROS et al) 13 November 2001 (13.11.2001).	39-63 and 66
A	US 6,023,929 A (MA) 15 February 2000 (15.02.2000).	39-63 and 66

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 March 2003 (14.03.2003)	08 APR 2003
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703)305-3230	Authorized officer Jason M. Greene Telephone No. 703-308-0661

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INTERNATIONAL SEARCH REPORT

PCT/US02/40107

Continuation of B. FIELDS SEARCHED Item 1:
55/282.3, 284, 302, 303, 385.3, 392.1, 394, 423, 428.1, 429, 432, 433, 523, DIG.10, DIG.30; 60/274, 295, 296, 297, 299, 301, 303, 311